

SECTION 4

FIRST-TIER SCREENING OF TECHNOLOGIES

4.1 TECHNOLOGY SURVEY

A survey of refuse recycling technologies was conducted to identify state-of-the-art and innovative ideas for volume reduction and recycling of refuse currently being sent to Waimanalo Gulch Landfill. The survey, which identified over 50 different recycling methods, included the following sources:

- **Municipal Solid Waste Programs.** A survey of the various municipal solid waste systems was conducted to obtain information on new technologies that have been considered by municipalities in the United States.
- **Literature Survey.** A literature survey (EPA, state and municipalities) was conducted to identify existing, new and emerging technologies implemented or proposed for municipal waste reduction.
- **Vendor Survey.** Various vendors were contacted to obtain data on their proposed waste management technologies.

Information on the technologies obtained during the survey was reviewed and each technology was grouped according to the waste stream application. Information gathered during the survey is included in the Appendix (bound separately).

4.2 CRITERIA USED FOR FIRST-TIER SCREENING OF TECHNOLOGIES

The purpose of the first-tier screening process was to reduce the number of technologies identified during the survey to approximately seven technologies. This screening process was performed through a figure-of-merit (FOM) evaluation method. This method involves first defining a set of screening criteria and then scoring each option against the given criteria. The total score developed during the FOM process is used to rank the technologies. The highest scoring technologies are selected for further evaluation.

The criteria used for FOM screening are listed below.

- **Volume Reduction.** The ability of the system to reduce the volume of waste to be placed in the municipal landfills.
- **Recycling.** The ability of the system to recover resources for recycling and reuse.
- **Disposal Site Impact.** The ability of the system to minimize impact on the disposal media. For example, a desirable system would maximize long-term disposal site stability and reduce: 1) dispersion of material at the disposal site areas; 2) toxicity of waste and minimize leakage into the groundwater; 3) subsidence; and, 4) generation of gas.
- **Adaptability.** Ease of adoption within the existing City refuse management system. Alternatives requiring an immediate drastic change could be cost prohibitive or impractical.
- **Worker Safety.** The ability of the system to be operated by the City or contract workers within acceptable safety standards.
- **Availability.** The level of maturity of the system and degree by which the system can be immediately applied are evaluated under by this criterion. Systems that are fully developed, operational, time proven, and commercially available would rate a higher score than emerging, unproven technologies. A system with technology elements that have only lab scale or prototype application histories would not qualify under this criterion.
- **Protection of the Public Health and Safety.** The degree by which the system is able to ensure public health and safety is evaluated under by this criterion.
- **Complexity.** The degree of complexity of the system and its ease of operation and maintenance. Simpler systems are desirable because of less possibility of failure, higher operational availability, and higher level of efficiency.

- **Versatility.** The ability of the system to handle the expected waste stream. The physical characteristics of typical waste streams could vary widely. Systems that are versatile enough to accept a wide range of waste would rate a higher score than one that has limitations and requires extensive sorting and segregation.
- **Environmental Friendliness.** The measurement of environmental friendliness will depend on the impact of the technology on human health and the environment. Technologies that minimize air emissions, discharges to surface waters, and risk of releasing toxic material to the groundwater are generally defined as “environmentally friendly” technologies.
- **Technical Risk.** Technical risk addresses the probability of the technology to produce the expected results and performance. For example, a technology may appear to be technically sound for some waste streams, but adoption to another waste stream being considered by the study may require a major redesign that could bring additional complexities and, hence, uncertainties.
- **Regulatory/ Permitting Risks.** The degree of uncertainty involved with the ability to obtain a construction and operating permit for the technology. The extent and complexity of permitting will depend on air emissions and any discharge to the surface waters. Systems that have minimal air emissions and zero liquid discharge are the most desirable approach. Technologies that minimize potential leakage into the groundwater will receive a high score. Also, proven past permitting will be considered as a positive point.
- **Economic Risks.** The lifecycle cost performance for the technology will be defined. The economic risk criteria address the degree of confidence regarding the system’s ability to perform within the estimated life-cycle costs. For example, if a technology has already been commercialized and has had previous operating experience, it is reasonable to assume that its cost can be quantified within a reasonable level of certainty. If the system is too complex and there are lots of unknown factors relative to its capital, operating, and maintenance costs, then the risk associated with cost overruns would be high and the system would receive a low score.

- **Schedule Risks.** This criterion evaluates the degree of uncertainty associated with acquiring and implementing a given technology. For example, if a system is still in the research and development stage, the probability of commercializing such system within the given time-frame might be lower than a system that is commercially available through a vendor.

4.3 FIRST-TIER SCREENING OF TECHNOLOGIES

Using the FOM method, the technologies were compared, assessed and ranked against the evaluation criteria. Additional data, including a summary of functional and operational requirements, were developed as necessary to allow a more thorough evaluation.

Each of the technologies was rated as low, medium or high. A corresponding score of one (1) was assigned to a low level of compliance with a given criterion, a score of two (2) was assigned to a medium level of compliance and a score of three (3) was assigned to a high level of compliance.

The technologies were then ranked based on the total score for each technology. The seven (7) technologies with the highest total scores were selected for further consideration.

A brief description of the selected technologies is presented below. Conceptual flowcharts are attached as **Figures 4-1 through 4-7**. Selected articles on the seven technologies are included in Appendix A of this report.

The seven technologies can be used in numerous system variations. Some of these variations are discussed below.

4.3.1 Alternative 1, Plasma Oxidation/Vitrification Followed by Conversion of Heat to Electricity in a Boiler

Alternative 1 uses thermal oxidation of waste materials in plasma and joule heated process chambers. The combined electrical heating destroys all of the organic compounds contained in the refuse and vitrifies the inert material into a glass or rock-like matrix. The thermal reactor is stationary (fixed-hearth), uses conventional technologies and accessories and can process a wide variety of materials to produce a totally inert residue that can be beneficially employed as an aggregate or filler. A steam boiler is included for energy recovery.

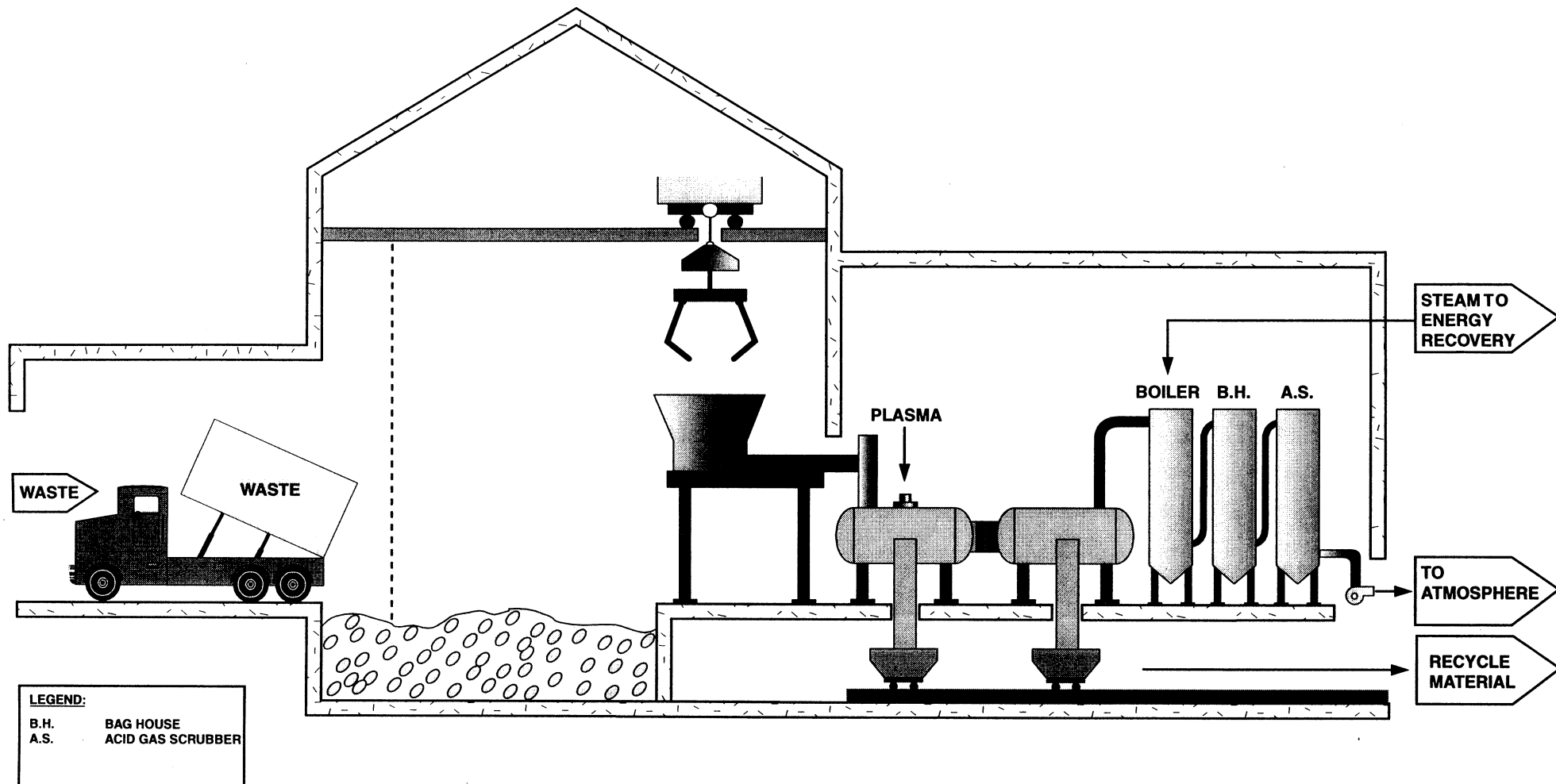


FIGURE 4-1

Alt 1. PLASMA OXIDATION/VITRIFICATION

ATG INC.

47375 FREMONT BOULEVARD
 FREMONT, CA 94538

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 OF HONOLULU
 NEW SYSTEMS RESEARCH

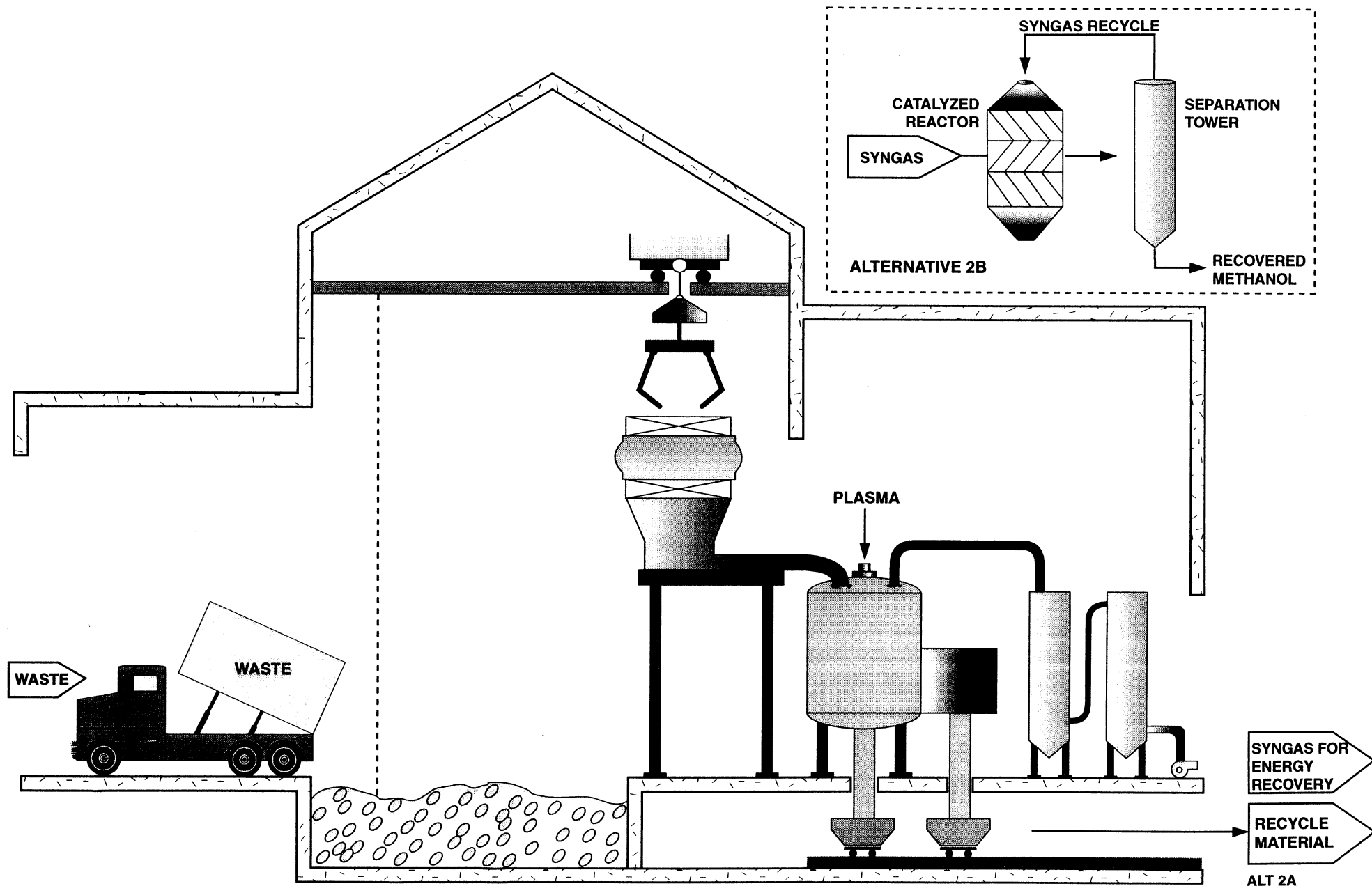


FIGURE 4-2

ALT 2. PLASMA GASIFICATION/VITRIFICATION

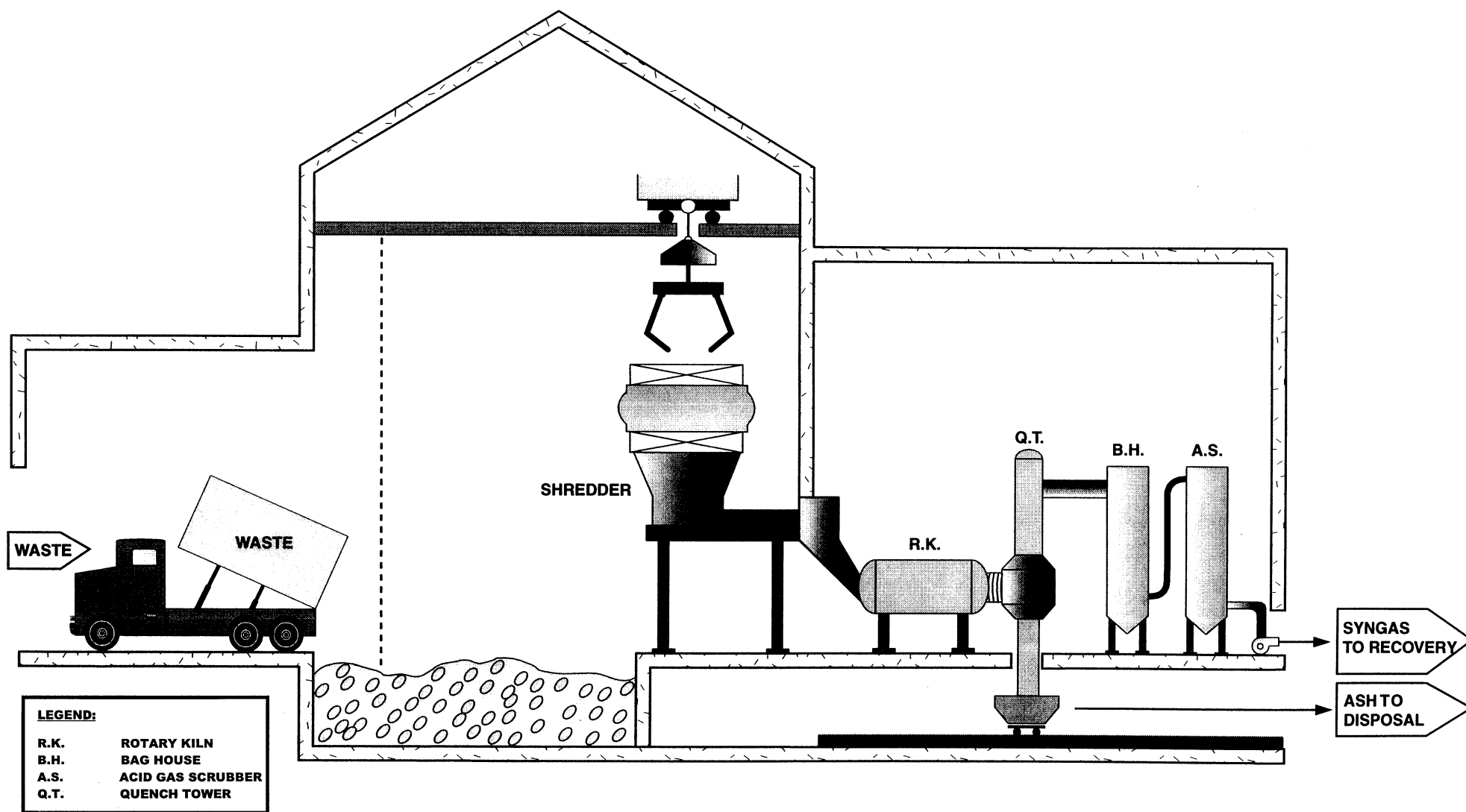


FIGURE 4-3

**ALT 3. ROTARY KILN GASIFICATION SLAGGING
FOLLOWED BY METHANOL RECOVERY**

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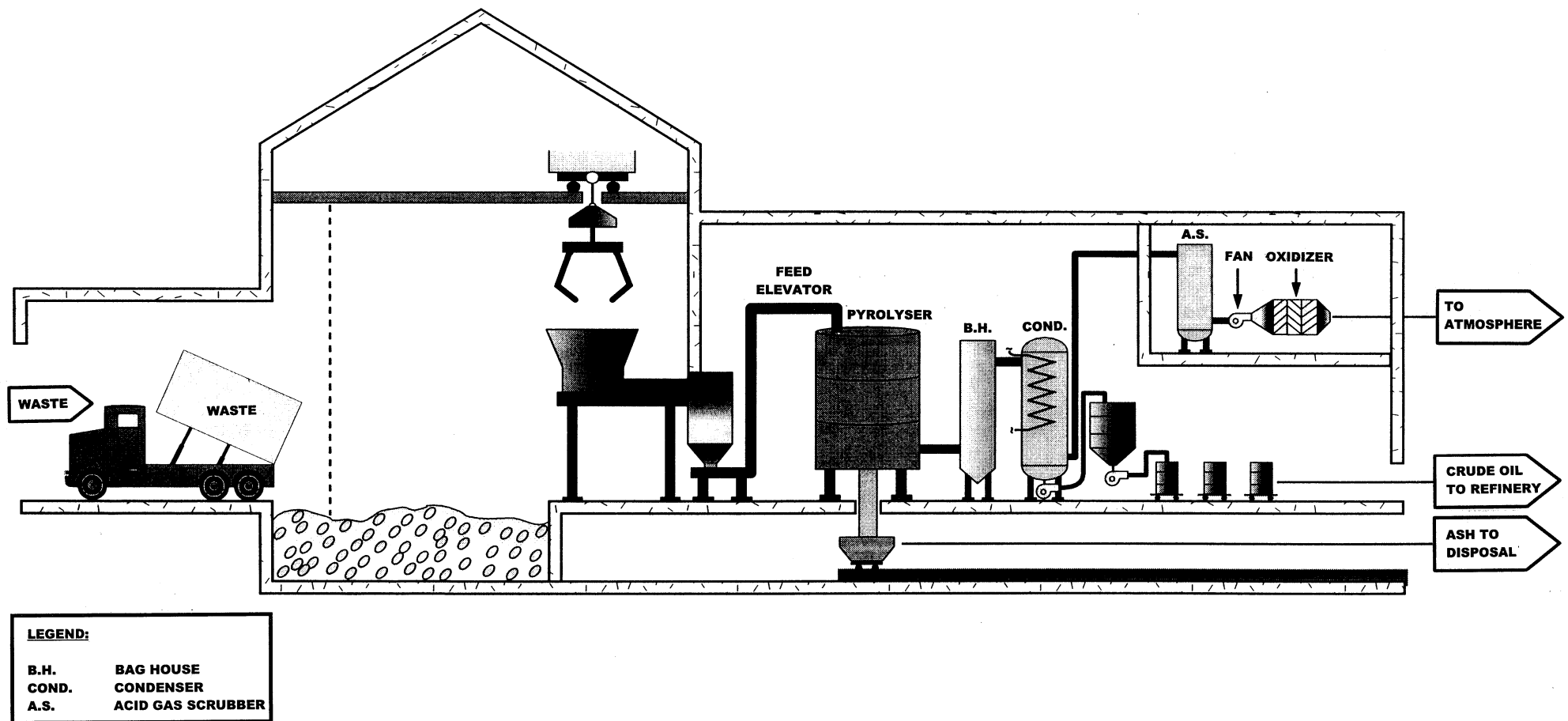


FIGURE 4-4

ALT 4. LOW-TEMP PYROLYSIS/OIL RECOVERY

199/FF/PROPOSAL DEPT

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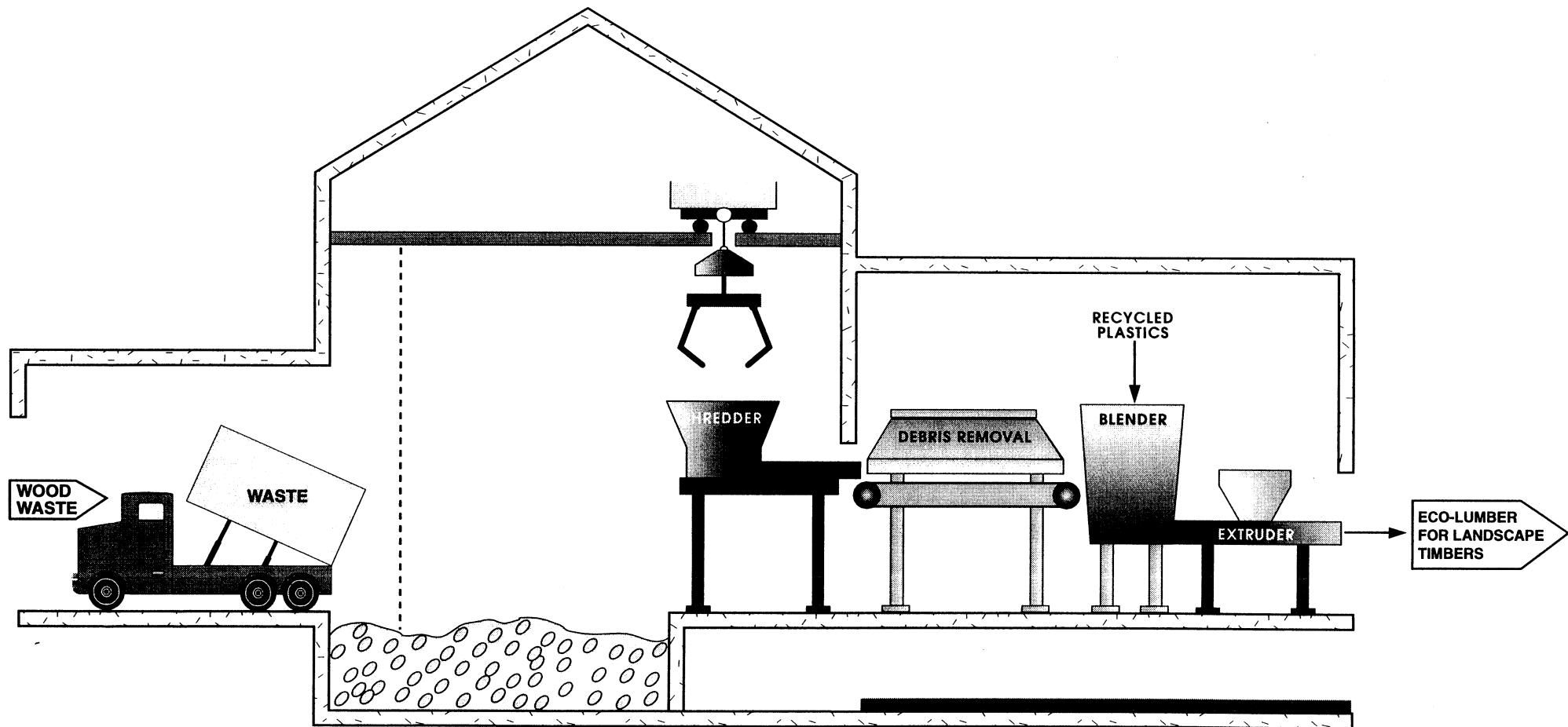


FIGURE 4-5

ALT 5. CONVERSION OF WOOD/PLASTIC WASTES TO ECO-TIMBERS

199/FF/PROPOSAL DEPT

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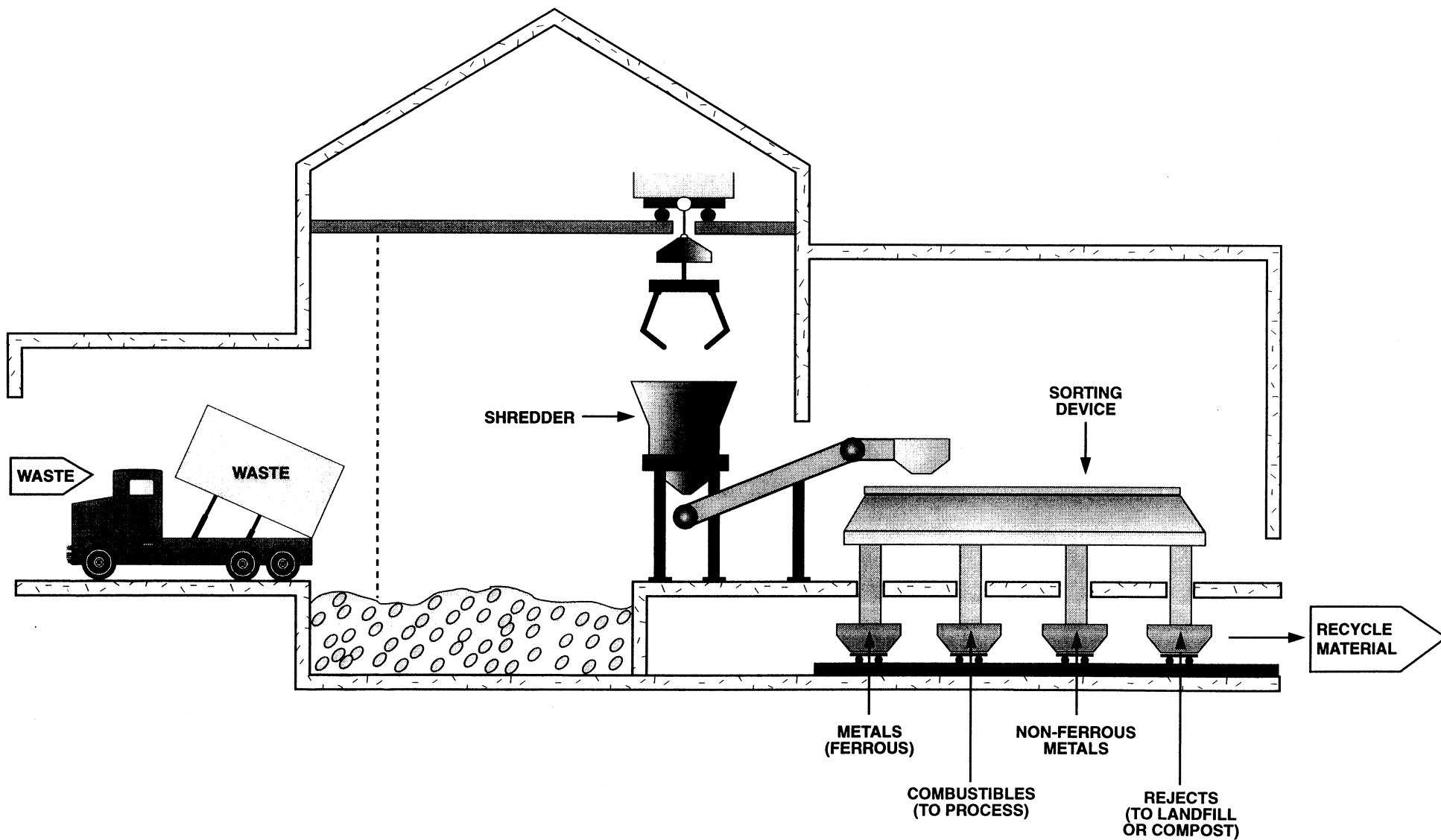


FIGURE 4-6

ALT 6. METALS RECOVERY

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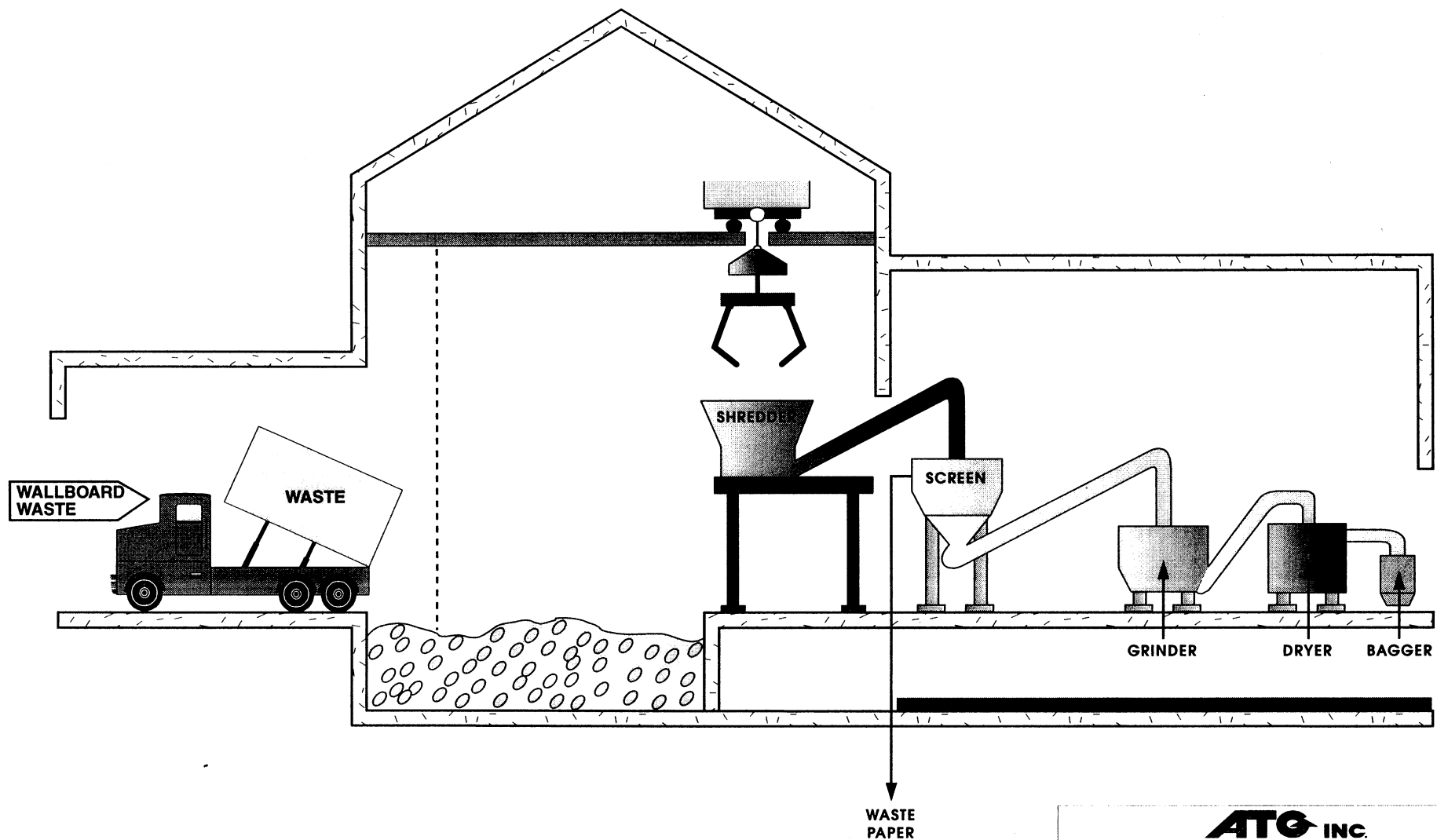


FIGURE 4-7

ALT 7. GYPSUM RECYCLE FROM WALLBOARD

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Advantages include a relatively simple operation, proven technology, multiple supplier sources, waste-heat recovery and product recovery in the form of a glass-like material. Disadvantages are low thermal efficiency and potential high risk in permitting.

4.3.2 Alternative 2, Plasma Gasification/Vitrification

Alternative 2 uses thermal gasification/vitrification of refuse materials in plasma and joule heated process chambers. A series of high-temperature plasma torches are used to decompose all organic components and melt inorganic residues into a rock-like glass material. It employs a combined-cycle gas turbine to generate power from the synthesis gas formed by the gasification of organic materials. Plasma temperatures reach 3,000-5,000° F so most organic compounds break down into their elemental components. Any water present reacts with elemental carbon to form carbon monoxide, resulting in a synthesis gas (syngas) that is primarily composed of hydrogen and carbon monoxide.

Alternative 2 can be implemented by using many different energy recovery methods. Two different methods, designated as alternatives 2A and 2B are described below:

- **Alternative 2A, Syngas Conversion to Electricity in a Turbine Generator.** In this alternative, the syngas is used to fuel a turbine power generator. A combined-cycle gas turbine generator is reputed to have as much as twice the energy efficiency of typical waste-to-energy thermal boilers. Advantages of this approach include size efficiency, energy recovery efficiency and revenue from the sale of electricity. A disadvantage is that this technology is relatively immature.
- **Alternative 2B, Syngas Conversion to Methanol.** In this alternative, the syngas is used to produce methanol. Methanol is easily produced from syngas in a high-pressure catalyzed reactor. It is a potentially useful transportation fuel, possibly more of a benefit to the Islands than production of electricity. Advantages of alternative 2B are the same as for alternative 2A, except that there may be a particular advantage to producing some product that is now being imported at a high price, transport fuel for example. Disadvantage is higher capital cost than alternative 2A.

4.3.3 Alternative 3, Rotary Kiln Gasification/Slagging Followed by Methanol Recovery

Alternative 3 uses a more conventional process chamber for converting refuse to methanol. Rotary-kiln gasifiers are designed much like cement kilns, consisting of a long, slowly revolving reaction chamber where heat decomposes organics in refuse into syngas. They have a longer history of operation and have been operated in much larger sizes than plasma vitrification units. Operating temperature is about 2000°F, compared to possibly 3000-5000°F for plasma. Rotary kiln gasifiers can be operated to produce either ash or slag (glass) as the residual. Experience with hazardous waste processing has developed reliable gas-scrubbing systems and cost information in similar-size operations. Like plasma gasifiers, the syngas could be converted to electricity, methanol, or other products.

An advantage is that this technology is more mature than the process used in Alternative 2. Disadvantages are that the unit would use natural gas or oil burners to heat the waste and the operation is anticipated to be more complex.

4.3.4 Alternative 4, Low-Temperature Pyrolysis Followed by Oil Recovery

Low-temperature pyrolysis, also called destructive distillation, operates at lower temperatures than gasification and produces a heavy oil product and a “char” residue that may be burned to heat the reaction chamber. This technology can recover black-carbon. The technology has received significant development during the 1970s as a method for recovering oil from shale deposits. The apparatus is an anaerobic heated reaction chamber, usually a batch reactor, and a condenser to recover the oil. Gas phase byproducts are usually fired in the reactor-heating unit.

Advantages are that capital and operating costs are projected to be lower than for gasification and that the technology is highly regarded by the environmental community. Pilot-scale operations have produced a usable fuel oil. There are specific processes developed in Europe for recycling treated wood. Disadvantages include the undeveloped state of this technology relative to municipal waste and the consequent lack of data on performance and cost.

4.3.5 Alternative 5, Conversion of Wood and Plastic Waste to ECO-Lumber

Alternative 5 is a method of grinding waste wood into fibers, blending the fibers with powdered or melted plastic and extruding the mixture as a monolithic composite material. It was included primarily as a low-cost way to process treated wood, but it also could be used as a method of transforming a majority of the waste stream into a useful product. There are commercially

available composites of wood fiber and plastic, but so far, none of the identified products uses recycled plastic or post-consumer waste wood (except clean sawdust from milling operations).

Wood, paper and plastic together comprise 54.7% of the waste stream (see Table 3-1), if furniture and carpet are included. The ratio of plastic materials to wood (including paper) is about 1:4, roughly the ratio of plastic to wood in commercial composites. There is little chance of producing a high-quality aesthetic product for home flooring or decorative use from an uncertain and varying feedstock. However, there are many possible uses, such as culvert piping, landscape timbers, parking lot dividers and sea wall timbers, that would tolerate greater variation in product characteristics than the “architectural” products that are currently produced.

The NSR study envisions this as a more risky “development opportunity” rather than a fully commercial opportunity. Although an operation of this size has not been proven, if successful, it has the potential, based on the vendors’ cost and revenue estimates, to save significantly more dollars per year compared to other options. ROM capital cost and claimed “production” costs for commercial materials are far below other options. Sale of the product is the key to success, and vendors’ claims of product value have been greatly discounted due to the decidedly different nature of a product made from variable materials.

Advantages are a projected low cost, use of well-developed commercial process machinery, the ability to recycle treated wood and a projected valuable product. Disadvantages are the early state of development, uncertainties about the product and lack of operating data.

4.3.6 Alternative 6, Metals Recycling

Metals recovery and recycling alternative uses magnetic fields and eddy currents to remove metals from a stream of shredded waste that passes by on a belt conveyor or similar device. Typically, magnets recover ferrous metals and eddy-current devices remove non-ferrous metals.

There are other ways to separate the metals from the waste at the landfill. Loads with large amounts of metal can be tipped in a separate area of the working face and a magnet used to remove the ferrous metal. After the metal is removed, the waste is covered as usual. This method will not work with non-ferrous metals.

Advantages are that alternative six is a relatively low-cost, low-risk operation that is already common in the industry. It addresses a relatively small portion of the waste stream, but at low cost. There is some potential for direct profit from recycled materials. Numerous vendors are available for metal-recovery operations, and most of such operations are profitable. Metals comprise 12.3% of the waste stream and possibly a significant portion of the “furniture/mattresses” stream (5.1%) as well. Metal recovery is beneficial to the other technologies being considered by reducing potential handling difficulties and abrasion, as well as by reducing the volume of the waste stream. Disadvantage is that metals recovery addresses only a small portion of the waste stream and therefore diverts little from the landfill.

4.3.7 Alternative 7, Gypsum Recycling

Recovering gypsum from wallboard is simple and represents approximately 7% of the volume of the refuse stream being sent to the Waimanalo Gulch Landfill. Some of the gypsum waste identified as being disposed at the Waimanalo Gulch Landfill is mixed with other materials and some is painted or wall papered. If mixed with other materials, it may not be useable as described in this alternative. If coated with paint or wallpaper, it may not be useable due to the difficulty of removing the coatings.

Gypsum is widely used as a soil amendment, and the projected volume of 15,000 tons per year would justify a dedicated operation, either by a contractor or directly by the City. Gypsum is recovered by grinding the wallboard, often in two stages, removing any metals, screening out the paper, drying and bagging the gypsum powder. Advantages are low cost, proven technology, simple operation. Disadvantage is that gypsum recovery addresses only a small portion of the waste stream.

4.4 TECHNICAL DISCUSSIONS

Following is a discussion of some of the issues that must be considered in the selection of the technologies.

4.4.1 Sorting

The review found that the level of sorting required before processing is an important consideration in the system complexities and the capital and operating costs. The technologies listed above all require some level of sorting. Alternatives 1, 2 and 3 include removing metals through an automated sorting process, consisting of shredding and magnetic removal of the ferrous metals. Additional sorting, such as removing and recycling wallboard, would be helpful

and probably cost effective. Alternative 4 benefits strongly from removal of additional inorganic materials besides the metals and wallboard since the “char” left after distilling the organic liquids will be fuel for heating the reactor. This is likely to be a hand-sort operation.

Alternative 5 is likely to include much additional sorting to improve the uniformity of the “product.” Some washing of the plastics might be included, and treated wood might be processed separately from untreated. Provision would be included for “backhaul” of materials judged to be unsuitable for including in the “product.”

4.4.2 Treated Wood

One of the most “problematic” materials in the specified stream is the treated wood refuse. This waste contains potentially toxic materials that limit the options for its diversion or volume reduction. Hence, any thermal technology employed to process the wood must contend with the toxic metals emissions. The plasma gasification/vitrification technology offers the most advantageous solution in dealing with the toxic contamination in the treated wood stream. This advantage stems from the following three factors:

- **Destruction of Organics in Wood Preservers.** The high temperature environment in the plasma process chamber ensures nearly total destruction of toxic organic compounds in the wood.
- **Capture of Solid Phase Metals in Wood Preservers.** The molten bath in the bottom of the plasma process chamber captures solid phase toxic metals, embedding them into a vitrified glass product.
- **Capture of Gaseous Phase Metals in Wood Preservers.** The plasma system’s relatively small offgas stream (about 10% of the standard oxidation processes) makes it economical to use a multi-stage gas treatment unit for efficient capture of the gaseous phase toxic metals.

4.4.3 Dirt and Yard Waste

Dirt and yard waste are already addressed by existing composting programs. They and the food waste can be processed by the selected technologies but may be better addressed by composting. Any possible diversion of these materials to existing compost operations is a significant process benefit and probably a cost saving measure. However, separating these materials is expected to be more costly than disposal.

4.4.4 Fuels

Alternatives 2 and 3 include a gas production option for applications that can replace oil fuel with synthesis gas. Generating gas instead of electricity significantly lowers the facility cost. Converting the gas to methanol would add to the facility cost but produce a valuable product that could be used to power the City's vehicles, for example.

Alternative 5 includes the selective removal of wood, paper and plastics from the waste stream. The wood, paper and plastics would be processed separately and then blended into an extruded composite, suitable for landscape timbers, parking lot dividers and similar applications. The end product could also be pelletized to form a high Btu/ low ash "RDF," but the presence of a significant percentage of treated wood would limit the type of facility that could burn it while controlling metals emissions. Manual sort could be extended to separate treated from untreated wood, with the treated wood processed separately as landscape material and the untreated wood processed as RDF. Value of the RDF would depend on having a suitable use for the fuel, possibly to supplement H-POWER or as a home-heating product. Home wood-burning stoves are more common in colder climates, so the RDF might be an "export" product.

4.4.5 Electric Power

Alternatives 1, 2, and 3 have the potential to use and/or produce significant amounts of electrical power. A suitable location with full access to the electrical grid has been assumed. If fuels from the processes were to be useful in H-POWER, they would benefit from being located nearby. The demand for electric power has been assumed to be modest in selecting fuels instead of power as possible products from gasification processes.